REMARKS — General

By the above amendment, Applicants have amended the claims to define the invention more particularly and distinctly so as to overcome the technical rejections and define the invention patentably over the prior art.

1. In response to paragraph 6 in the last O.A., applicants canceled dependent claims 20, 25, 30, and 35, and amended independent claims 17 and 27 by adding limitations of "measuring confidences about the presence of the target object based on a combination of color and motion cues in each of the images captured by said imaging sensors", "the color and motion cues are spatially spread out using averaging before they are combined", and "initially distributing the 3D target location hypotheses randomly in spaces viewed by said imaging sensors". Applicants believe the independent claims are allowable with the reasons discussed in [pages 11-19 of the remarks in applicants' last amendment, (Amendment B)]. Accordingly, applicants respectfully request reconsideration of the currently amended claims 17 and 27.

2. In response to paragraph 9 in the last O.A., applicants canceled claims 26 and 36. Applicants added the limitations, "d) calculating locations of new hypotheses by adding offsets to locations of old hypotheses, wherein the offsets are randomly drawn between two numbers," and "d) means for calculating locations of new hypotheses by adding offsets to locations of old hypotheses, wherein the offsets are randomly drawn between two numbers," to currently amended claims 17 and 27, respectively.

Applicants disclosed the limitation in the specification filed on 7/12/2003, (Applicants, page 17, lines 8-13, and page 19, lines 11-14).

Applicants believe the limitation is clearly supported by the specification and more particularly define the invention in a patentable manner, with the reasons discussed in [page 25, line 16 – page 26, line 9 in applicants' last amendment, (Amendment B)]. Accordingly, applicants respectfully request reconsideration of the objection, as now applicable to the currently amended claims 17 and 27.

3. In response to paragraph 10 in the last O.A., applicants amended claims 17 and 27, so that the currently amended claims do not have the phrase "for combining the measurements".

The Rejection Of The Claims Under § 112

4. In response to paragraphs 11-30 in the last O.A., applicants amended claims as follows. Accordingly, applicants respectfully request reconsideration of this rejection.

5. In response to paragraph 12 in the last O.A., applicants canceled claims 26 and 36, and applicants added the limitations in the canceled claims to claims 17 and 27, respectively, as explained above in paragraph 2. The limitations in the claims, as now applicable to the currently amended claims 17 and 27, are supported in the specification filed on 7/12/2003, (Applicants, page 17, lines 8-13, and page 19, lines 11-14). Accordingly, applicants respectfully request reconsideration of the rejection with respect to claims 17 and 27.

6. In response to paragraph 15 in the last O.A., applicants amended claims 17 and 27, so that the currently amended claims do not have the phrase "examples...can", respectively.

7. In response to paragraph 16 in the last O.A., the limitation "the final target object location" has been replaced with the limitation "the 3D location of the target object" in the currently amended claims 17 and 27, respectively.

8. In response to paragraph 17 in the last O.A., the limitation "the weighted mean" has been replaced with the limitation "a weighted mean" in the currently amended claims 17 and 27, respectively.

9. In response to paragraph 18 in the last O.A., the limitation "the measurements" has been removed in the currently amended claims 17 and 27, respectively.

10. In response to paragraph 19 in the last O.A., claims 19 and 29 have been canceled.

11. In response to paragraph 20 in the last O.A., claims 19 and 29 have been canceled.

12. In response to paragraph 21 in the last O.A., claims 19 and 29 have been canceled.

13. In response to paragraph 22 in the last O.A., claims 20 and 30 have been canceled. As explained above in paragraph 1, the limitation "a combination of color and motion cues" has been added to the currently amended claims 17 and 27, respectively.

14. In response to paragraph 23 in the last O.A., claims 20 and 30 have been canceled. The limitation "the edges" has been canceled, respectively.

15. In response to paragraph 24 in the last O.A., claims 20 and 30 have been canceled. The limitation "the interior" has been canceled, respectively.

16. In response to paragraph 25 in the last O.A., the limitation "of the new hypotheses" has been replaced with the limitation "in the weighted mean of all 3D target location hypotheses" in the currently amended claims 23 and 33, respectively.

17. In response to paragraph 26 in the last O.A., the limitation "the weights" has been replaced with the limitation "weights" in the currently amended claims 23 and 33, respectively. The "weights" are "in the weighted mean of all 3D target location hypotheses" in the currently amended claims 23 and 33, respectively.

18. In response to paragraph 27 in the last O.A., claims 25 and 35 have been canceled. As explained above in paragraph 1, the limitation "spaces viewed by said imaging sensors" has been added to the currently amended claims 17 and 27, respectively.

19. In response to paragraph 28 in the last O.A., applicants amended the claims to read so that all "location hypotheses" that correspond to the "3D target location hypotheses" to read the same. Regarding claims 19 and 29, they have been canceled.

20. In response to paragraph 29 in the last O.A., the limitation "step of d) projecting each of the 3D target location hypotheses" has been added to claim 18, the limitation "step of b) maintaining a large number of 3D target location hypotheses" has been added to claim 23, the limitation "d) means for projecting each of the 3D target location hypotheses" has been added to claim 28, and the limitation "b) means for maintaining a large number of 3D target location hypotheses" has been added to claim 33 to clarify these steps and means correspond to the steps and means claimed in the corresponding independent claims, respectively. Regarding claims 19-20 and 29-30, they have been canceled.

21. In response to paragraph 30 in the last O.A., the limitation "maintaining 3D target location hypothesis" has been removed in the currently amended claims 23 and 33, respectively.

Regarding claims 24 and 34, they have been canceled.

Regarding claims 26 and 36, they have been canceled.

The Rejection Of The Claims Under § 103

22. The last O.A. rejected claims 17-36 under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6999624 (Nelson) in view of U.S. Patent Application Publication No. 20010008561 (Paul et al, hereinafter Paul), and further in view of U.S. Patent No. 5323470 (Kara et al, hereinafter Kara).

Applicants amended the claims as follows:

The Rejection Of Claim 27 on Nelson, Paul, and Kara Overcome

23. Applicants request reconsideration of the rejection, as now applicable to the currently amended claim 27, for the following at least five reasons:

(1) Target object tracking based on novel usage of multiple 3D target location hypotheses is clearly foreign to Nelson, Paul, and Kara. The novel step in the present invention was not suggested in the reference or any prior art, produces new and unexpected results, and hence is unobvious and patentable over the reference.

(2) Random distribution of the hypotheses is foreign to Nelson, Paul, and Kara, and the focus of the idea in Paul with regard to the initialization of target object location is contradictory to that of the present invention.

(3) Modeling arbitrary shape and contour of the target object is foreign to Nelson, Paul, and Kara.

(4) There is no justification in Nelson, Paul, and Kara, or in any other prior art separate from applicants' disclosure, which suggests that these references be combined, much less be combined in the manner proposed.

(5) Since the fundamental approaches in applicants' system are clearly foreign to Nelson, Paul, and Kara, even if Nelson, Paul, and Kara were to be combined in the manner proposed in the last O.A., the proposed combination would not show all the novel features of claim 27.

The novel and unobvious approaches in applicants' system are clearly foreign to Nelson, Paul, and Kara, and they were not suggested in the reference or any prior art. Applicants respectfully note that the significant differences in the approaches between applicants' present invention and Nelson, Paul, and Kara are not to be underestimated or misunderstood.

Target Object Tracking Based On Novel Usage Of Multiple 3D Target Location Hypotheses Is Clearly Foreign To Nelson, Paul, and Kara

24. Applicants noted, "Projective geometry states, that we can obtain from the projected locations r_L and r_R of a point R, the corresponding 3D coordinate through triangulation. Most stereo algorithms rely on this principle by finding correspondences between two images and recovering depth through triangulation. However, finding correspondences between views is challenging," (Applicants, page 10, lines 3-7).

As a solution to the challenge, applicants disclosed a novel approach to the problem with the measurement of the confidence in the hypothesis as in "given a hypothesized hand location in world coordinates *R*, the image data is used to measure the confidence in this hypothesis, i.e., the degree to which the image data supports the hypothesis that a hand is indeed present at the 2D locations corresponding to the world coordinate R" (Applicants, page 10, lines 11-14).

Especially, to increase the accuracy of the approach, applicants disclosed, "a large number of such hypotheses are maintained and combined to get a statistical measure of the true

hand location in world coordinate space" (Applicants, page 10, lines 14-16). "In the illustration FIG. 11, the value is N=14 but in practice, this number is much larger." (Applicants, page 16, lines 7-8). Typically, in an exemplary embodiment of the present invention, the number of hypotheses could be between 40 and 500, but depending on the parameters, such as the size of a hand, the number could be more or less.

The usage of "a large number of such hypotheses" is clearly foreign to Nelson, Paul, and Kara.

As the last O.A. also noted, Nelson did not explicitly disclose the usage of "a large number of 3D location hypotheses". Nelson's "overlapping windowed portions" in (Nelson, column 3, lines 42-46) is clearly different from the "3D target location hypotheses" in applicants' present invention.

In addition, Nelson explicitly disclosed the grouping process of the windows in (Nelson, column 6, lines 18-28), which is clearly irrelevant to the "3D target location hypotheses" in applicants' present invention.

Furthermore, Nelson explicitly disclosed the group score calculation process in "with the groups of possible target windows being formed, the method of the present invention next calculates a group score at step 40 for each group. Each group score is based on the maximum of one or several classification scores for each of the possible target windows assigned to that group." (Nelson, column 6, lines 29-33). Nelson further discussed some examples of the group score calculation in (Nelson, column 6, lines 34-52).

This clearly shows Nelson's approach in the window grouping process and group score calculation are clearly foreign to the "3D target location hypotheses" in applicants' present invention.

Paul explicitly disclosed, "The system tracks objects based on the color, motion and shape of the object in the image. The tracking algorithm uses a unique color matching technique which uses minimal computation. This color matching function is used to compute three measures of the target's probable location based on the target color, shape and motion. It then computes the most probable location of the target using a weighting technique." (Paul, page 1, paragraph 10).

Paul clearly noted that their system "tracks objects based on the color, motion and shape of the object in the image" using "a unique color matching technique". Applicants' present invention uses only color and motion cues. Regarding the "shape", as discussed in (Applicants' amendment B, page 15, line 1 – page 17, line 3), applicants' present invention tries to avoid using the shape-based approach for target object tracking.

Furthermore, Paul clearly noted, "It then computes the most probable location of the target using a weighting technique." Paul did not disclose the novel usage of "a large number of 3D location hypotheses" in relation to the "probable location" in anywhere in their disclosure, and Paul is entirely foreign to the concept.

Especially, in the description for the "Color Matching" (Paul, page 2, paragraph 24 – page 3, paragraph 31), Paul explicitly disclosed, "The two thresholds will decide the shape of the matching color cone. A threshold on the angle of the color cone and another threshold on the minimum length of the color vector decides the matching color space. Thus, any pixel whose

color lies within the truncated cone in color space will be considered as having the same color as the target." (Paul, page 2, paragraph 26) and "ColorMatch (R , G , B) = { d m d a if ((d m l < d m < d m h) & (d l l < d a < d a h)) 0 otherwise" (Paul, page 2, paragraph 27), which is clearly different from the confidence measure (values between zero and one) that is given by the function 1.1 in (Applicants, page 11, line 17).

In Paul's description for the motion detection (Paul, page 3, paragraphs 35-40), Paul also did not explicitly disclose the novel usage of "a large number of 3D location hypotheses"

Neither Nelson nor Paul disclose the novel usage of "a large number of 3D location hypotheses" (please also refer to Applicants, page 16- page 17 and Fig. 11 and 12) in anywhere in their disclosure, and they are clearly foreign to the concept. Kara is foreign to the idea. Therefore, there is no logical explanation that the combination of the three prior arts can create the same result in the manner applicants' present invention proposed.

Random Distribution Of The Hypotheses Is Foreign To Nelson, Paul, and Kara

25. Applicants disclosed random distribution of the hypotheses at the starting point of the hand tracking, "The target location hypotheses H_i are generated over time as follows: When the method starts (say at time t=0), and no information from the past is available, the R_t^i at time t=0 are randomly distributed in the interaction volume 400. For all later times t>0, N new hypotheses are created from the N old hypotheses available from the previous time step *t-dt* as follows: For the creation of the *i-th* (*i* between 1 and N) hypothesis, a number *j* between 1 and N is randomly drawn such that the probability of drawing a number *n* is equal to the probability W_{t-1}^n." (Applicants, page 17, lines 2-8). This approach is clearly foreign to Nelson, Paul, and Kara.

Furthermore, Paul explicitly suggested the usage of a user's manual input for the initialization step, as shown "It then allows the user to select the target manually using the mouse or automatically by moving the target to a predetermined position in the scene. At the point of initialization, the color, the shape and location of the target are computed and stored." (Paul, page 2, paragraph 20, please also refer to Paul, page 1, paragraph 11, and Paul, page 2, paragraph 18), which the present invention identifies as a problem in an automatic object tracking system and the novel approach of the present invention overcomes.

Applicants' preliminary preparation step, such as the calibration of the cameras, uses manual input for determining the image locations of the calibration point.

However, the tracking of the target object in applicants' system is processed completely automatically without requiring any manual initialization.

This further shows the approach and focus of the idea in Paul is contradictory to that of the present invention.

Furthermore, claim 27 further adds limitation of means for calculating locations of new hypotheses by adding offsets to locations of old hypotheses, wherein the offsets are randomly drawn between two numbers.

Applicants explicitly disclosed, "For all later times t>0, N new hypotheses are created from the N old hypotheses available from the previous time step *t-dt* as follows: For the creation of the *i-th* (*i* between 1 and N) hypothesis, a number *j* between 1 and N is randomly drawn such that the probability of drawing a number *n* is equal to the probability W_{t-1}^{n}. The location of the new *i-th* hypothesis is given by the location of the old hypothesis plus a small offset $\Delta R_t^i = (\Delta X_t^i, \Delta Y_t^i, \Delta Z_t^i)$, where each of the three offsets $\Delta X_t^i, \Delta Y_t^i, \Delta Z_t^i$ are randomly drawn

between two numbers –OFFSET and +OFFSET (– 5mm and +5mm for the preferred embodiment described here). The weight of the new hypotheses with location $R_t^i = R_{t-1}^j + \Delta R_t^i$ is given by the confidence function $CONF_{LR}(R,t)$." (Applicants, page 17, lines 5-14).

Nelson is entirely foreign to the idea of drawing random displacements and adding them to the 3D target location hypotheses, especially for tracking a target object, since Nelson is only a method for classifying targets in a digital image rather than a method for tracking a target object.

Modeling Arbitrary Shape And Contour Of The Target Object Is Foreign To Nelson, Paul, and Kara

26. As discussed above, applicants' system is based on a novel usage of multiple hypotheses for target object tracking, and "In step 1440, N new hypotheses are created from the hypotheses at the previous time step t-dt by randomly selecting previous hypotheses with probability equal to the hypothesis weights" (Applicants, page 19, lines 11-13). Then, "the locations of the newly selected hypotheses are displaced randomly in step 1450." (Applicants, page 19, lines 13-14).

Therefore, applicants' present invention is not bound by any fixed shape or contour of a certain target object model because the locations of the "N new hypotheses" can change randomly at every step. This capability of modeling any arbitrary shape and contour for the target object is foreign to Nelson, Paul, and Kara. Nelson's approach for the classification of targets does not teach a method for tracking target objects. Paul explicitly disclosed a usage of a shape matching in (Paul, page 3, paragraph 32-34). Kara teaches, "comparing a pre-stored image of the object with the current image from the camera." in (Kara, column 5, lines 12-21).

Nelson, Paul, and Kara Do Not Contain Any Justification To Support The Combination, Much Less In The Manner Proposed

27. Due to the differences mentioned above in the fundamental approaches for applying computer vision algorithms, there is a significant lack of proof that supports the proposed combination in the last O.A. Since Nelson, Paul, and Kara do not show the novel and unobvious features in applicants' present invention, there is clearly no logical connection that suggests the proposed combination. Furthermore, the prior arts themselves do not contain any suggestion that they be combined in the manner proposed.

Fundamentally, Nelson is a method of classification of targets in a digital image by evaluating windowed portions of the image, and Nelson is entirely foreign to the idea of target object tracking based on novel usage of multiple target location hypotheses. It is well known that the tasks in the classification of a target object in an image are non-trivially different from those in the tracking of a target object in the practiced art. There is clearly no justification that Nelson can suggest the ideas of tracking a target object utilizing 3D target location hypotheses in the manner proposed in the present invention.

Even If Nelson, Paul, and Kara Were To Be Combined In The Manner Proposed, The Proposed Combination Would Not Show All The Novel Features Of Claim 27

28. Even if the combination of Nelson, Paul, and Kara were legally justified, claim 27 would still have novel and unobvious features over the proposed combination, since the fundamental approaches in applicants' present invention are clearly foreign to Nelson, Paul, and Kara.

Specifically, clauses (b), (c), (d), (e), (f), and (g) clearly distinguish applicants' present invention from Nelson, Paul, and Kara, or any possible combination thereof. None of Nelson, Paul, and Kara shows the features in clauses (b), (c), (d), (e), (f), and (g).

29. In paragraph 33 of the last O.A., it is noted that claim 17 is rejected for the same reasons as claim 27, and claim 17 distinguishes from claim 27 only in that claim 17 is a method claim and claim 27 is an apparatus claim.

Applicants amended claim 17, which recites limitations that are similar and in the same scope of invention as to those in claim 27 above.

Therefore, applicants request reconsideration of the amended claim 17 for the same reasons as stated above in regards to claim 27.

The Dependent Claims Are a Fortiori Patentable Over Nelson, Paul, and Kara

30. Dependent claims 28 to 36 incorporate all the subject matter of claim 27 and add additional subject matter, which makes them a fortiori and independently patentable over the references.

Applicants amended the claims 28 to 36 as follows:

31. In response to paragraph 34 in the last O.A., claim 28 further adds means for utilizing projections that are obtained by calibrating said imaging sensors with respect to a reference coordinate system.

Applicants disclosed the usage of an exemplary calibration cube with eight calibration points, "as illustrated in Fig. 9, the camera calibration matrices are obtained by placing a calibration target such as a cube (1000) with a set of Nc calibration points (e.g., 1010a, 1010b) with known world coordinates in the viewing area. In FIG. 9, the calibration cube has Nc=8 calibration points." (Applicants, page 17, line 16 – page 18, line 17).

Paul disclosed, "At the point of initialization, the color, the shape and location of the target are computed and stored. Once the target is initialized, we compute an estimate of the target location using target dynamics. We then compute the actual location using the color, shape and motion information with respect to a region centered at the estimated location." (Paul, page 2, paragraph 20). The initialization is a clearly different process from the calibration process, and the step of projecting a large number of target location hypotheses based on the calibration process in the manner proposed by the present invention is not shown in Paul.

32. In response to paragraph 35 in the last O.A., claim 29 has been canceled.

33. In response to paragraph 36 in the last O.A., claim 30 has been canceled.

34. In response to paragraph 37 in the last O.A., claim 31 further adds means for calculating the color cues using a color model of the target object, wherein the color model of the target object is represented by a histogram that is estimated by collecting color samples of the target object.

The novel usage of color for calculating the color cues of the confidence measure as disclosed in (Applicants, page 11, line 1 – page 12, line 2), including the function 1.1 in (Applicants, page 11, line 17), is clearly foreign to Paul and Nelson. Neither Paul nor Nelson discloses how the color cues are used to measure confidences for the 3D target location hypotheses in the manner proposed in the present invention.

35. In response to paragraph 38 in the last O.A., claim 32 further adds means for calculating motion cues by measuring differences between images captured sequentially by the imaging sensors.

The novel usage of motion for calculating the motion cues of the confidence measure as disclosed in (Applicants, page 12, lines 3 – 20), including the function 1.2 in (Applicants, page 12, line 17), is clearly foreign to Paul and Nelson. Neither Paul nor Nelson discloses how the motion cues are used to measure confidences for the 3D target location hypotheses in the manner proposed in the present invention.

36. In response to paragraph 39 in the last O.A., claim 33 further adds means for creating a set of 3D target location hypotheses at each time step. The target location hypothesis maintenance disclosed in the manner proposed by the applicants' system (Applicants, page 17, lines 1-14) is entirely foreign to Paul.

Paul explicitly disclosed, "If motion has occurred, there will be sufficient change in the intensities in the region. The motion detection function will trigger if a sufficient number of pixels change intensity by a certain threshold value. This detection phase eliminates unnecessary

computation when the object is stationary." (Paul, page 3, paragraph 36), which is clearly different from the idea of creating a set of 3D target location hypotheses at each time step in "For all later times t>0, N new hypotheses are created from the N old hypotheses available from the previous time step t-dt as follows:" (Applicants, page 17, lines 5-7).

Furthermore, the novel step of creating a set of 3D target location hypotheses based on the confidence function CONFLR(R,t) (Applicants, page 17, lines 13-14, please also refer to function 1.3 in Applicants, page 14, lines 11-21 and function 1.4 in Applicants, page 15, lines 10-16) at each time step is entirely foreign to Paul. Paul only very briefly mentioned the usage of tracking for a target in 3D in "Another uses the tracking in two stereo images to track the target in 3D." (Paul, page 4, paragraph 45). This clearly shows that Paul is foreign to the idea of creating a set of 3D target location hypotheses based on the confidence function CONFLR(R,t).

37. In response to paragraph 40 in the last O.A., claim 34 has been canceled.

38. In response to paragraph 41 in the last O.A., claim 35 has been canceled.

39. In response to paragraph 42 in the last O.A., claim 36 has been canceled.

40. Accordingly, applicants submit that the dependent claims are a fortiori patentable and should also be allowed.

41. In paragraph 43 of the last O.A., it is noted that claims 18-26 are rejected for the same reasons as claims 28-36, and claims 18-26 distinguish from claims 28-36 only in that they have different dependencies.

Applicants amended claims 18-26, which recite limitations that are similar and in the same scope of invention as to those in claims 28-36 above, respectively.

Therefore, applicants request reconsideration of the amended claims 18-26 for the same reasons as stated above in regards to claims 28-36, respectively.

CONCLUSION

For all the above reasons, applicants submit that the specification and claims are now in proper form, and that the claims all define patentably over the prior art. Therefore they submit that this application is in condition for allowance now, which action they respectfully solicit.

Conditional Request for Constructive Assistance

Applicants have amended the specification and claims of this application so that they are proper, definite, and define novel structure, which is also unobvious. If, for any reason this application is not believed to be in full condition for allowance, applicants **very respectfully request** the constructive assistance and suggestions of the Examiner pursuant to M.P.E.P. § 2173.02 and § 707.07(j) in order that the undersigned can place this application in allowable condition.

Very respectfully,

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Date: 10/15/2007 Inventor's Signature: Fahamid